Benthic Foraminiferal Assemblages in the Clyde River Estuary, Batemans Bay, N.S.W.

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COTTER, K.L. Benthic foraminiferal assemblages in the Clyde River Estuary, Batemans Bay, N.S.W. Proc. Linn. Soc. N.S.W. 116, 193–208

The Clyde River Estuary was sampled to determine the distribution of foraminiferal assemblages. The River was sampled (34 localities) from its tidal limit at Shallow Crossing to the bridge at Batemans Bay, a distance of 41.25 kilometres. Thirty-six species (belonging to 21 genera) of foraminiferids were identified. The benthic populations of foraminifera were examined using Q-mode cluster analysis, the Fisher α Index and the constancy or presence of species. Three Assemblages were distinguished. These were the Upper Estuary Assemblage characterised by Textulariina and two assemblages from the Lower Estuary: Group A characterised by *Ammonia beccarii* and *Elphidium craticulatus*; and Group B which has these species but also a large Miliolidae content. The controlling factors on foraminiferal distribution are salinity, substrate and nutrient supply. Salinity controls the dominance of arenaceous foraminifera in the Upper Estuary and the limit to which calcareous forms can penetrate into lower salinity levels; the miliolinids are also constrained by salinity; nutrient supply appears to control the abundance of some species. The grain size of the substrate can be linked to the distribution of some species.

Manuscript received 16 Aug 94, accepted for publication 15 Feb 95.

KEYWORDS: estuary, foraminifera

INTRODUCTION

Previous studies of foraminifera in Australia include examinations of collections from Victoria, South Australia and Tasmania (Chapman, 1907, 1941; Parr, 1932, 1945). Later studies of estuarine environments include those in Western Australia from Oyster Harbour, near Albany (McKenzie, 1962) and the Hardy Inlet (Quilty, 1977). In Victoria foraminiferal distribution in Port Phillip Bay (Collins, 1974) and the Gippsland Lakes System (Apthorpe, 1980) have been studied.

Along the south-east coast of New South Wales, foraminiferal assemblages are known in Port Hacking (Albani, 1968), Broken Bay (Albani, 1978) including Pittwater (Johnson and Albani, 1973; Albani and Johnson, 1975), the Minnamurra River (Michie, 1975; 1982) and Lake Illawarra (Yassini and jones, 1989).

The Clyde River Estuary at Batemans Bay, located 285 kilometres south of Sydney, was sampled in September of 1979 and these findings have now been reviewed. The study concentrated on the tidal limit of the river from the bridge at Batemans Bay to Shallow Crossing, a distance of 41.25 kilometres (Fig. 1). The Clyde River was chosen for this study because foraminiferal distribution patterns had been documented further north in the Minnamurra River, NSW (Mitchie, 1975), and in the Gippsland Lakes System, Victoria (Apthorpe, 1980) to the south; the intervening area of coastal New South Wales had not been studied. The Clyde River is situated approximately midway between these two study areas. The only studies completed since 1979 in this region have been a comprehensive study of Lake Illawarra, NSW (Yassini and jones, 1989) which is again further to the north and the Malacoota Inlet, Victoria (Bell and Drury, 1992) to the south. The study aimed to define the benthic foraminiferal assemblages in the Clyde River Estuary and so provide a more comprehensive analysis of the south-east coast of Australia.

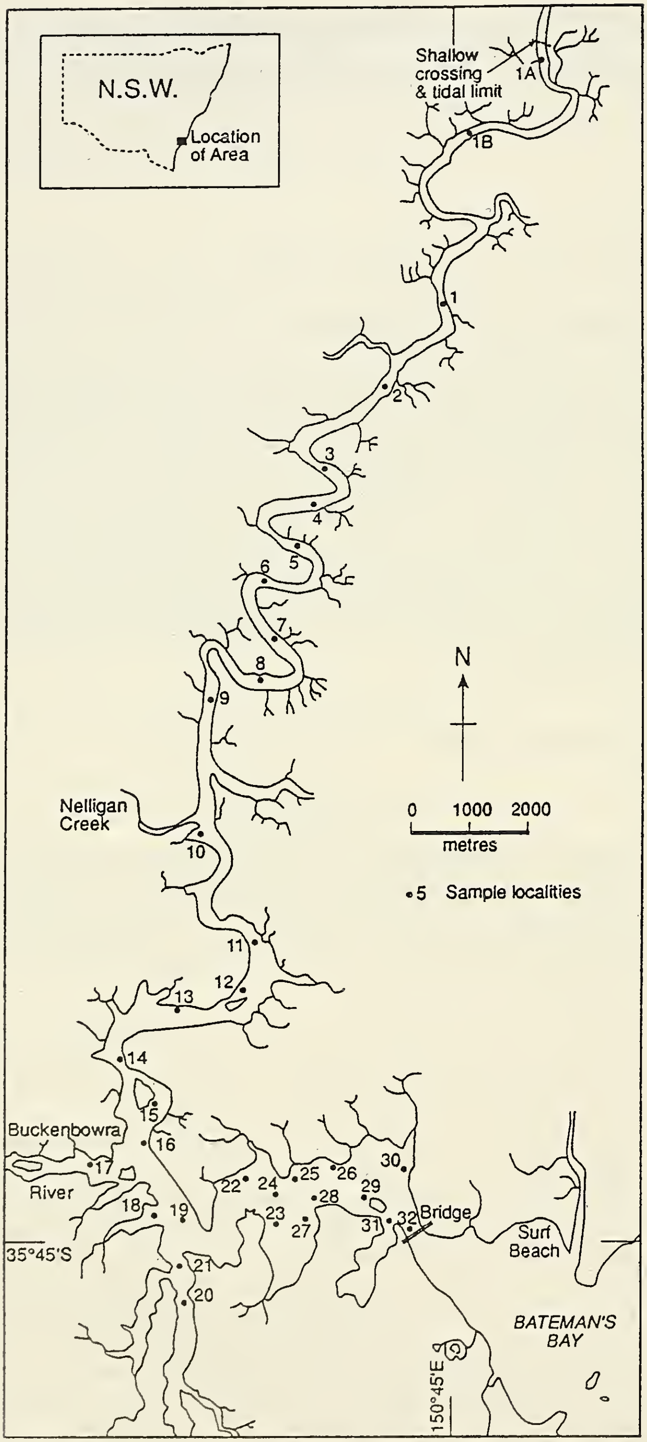

Fig. 1. Map of the Clyde River Estuary showing sample localities.

PARAMETERS OF THE CLYDE RIVER ESTUARY

The Clyde River rises in the Sassafras Tableland north of the Buddawang Range and travels southeast approximately parallel to the coast. At latitude 35°45´S the River turns east and broadens and slows leading to an increase in mangroves before emptying into Batemans Bay. Shallow Crossing marks the tidal limit of the river (Fig. 1). Lag gravel deposits extend downstream to a point between localities 4 and 5 where mud becomes an important part of the sediment. Sand-sized grains, and sediments of a larger grain-size, are found in the midstream along the length of the river while mud and silt sized particles occupy the areas near the banks. localities 9, 13, 16, 19, 21, 24 and 32 are located in central positions in the channel with grain sizes from gravel to coarse and fine sand.

The bathymetry of the Clyde River estuary is unknown and depth is only known for the sample localities. Most localities averaged 1–2m in depth the exceptions being those localities situated midstream in the tidal channel: 9 (6.4m), 13 (7.0m), 16 (4.5m), 19 (4.5m), 21 (7.0m), 24 (4.5m), and 32 (7.25m) Turbidity readings proved to be very variable from clear to 3m to turbid from the surface. The southeast coast of N.S.W. has a warm temperate climate with a seasonal distribution of rainfall with maximum precipitation in Autumn resulting in an average annual rainfall of 1000mm. Water temperature at a depth of one metre ranged from 10.5°C to 15°C in September. There was little difference between surface and bottom water temperatures.

There is a small tidal range in the Clyde River and all sampling was completed on a falling tide of 1 .6m in September. Salinity readings were taken at the time of sampling and ranged from 0‰ at locality lA (Shallow Crossing) to 32‰ at locality 32.

The river drains a State forest in its upper reaches. Down stream there is grazing activity around the small settlement of Nelligen and the expanding tourist industry in Batemans Bay has brought recreation to the river in the form of water skiing, fishing and recreational boating. A thriving oyster industry is located around the mangrove areas in the lower estuary.

METHODS

Sampling was completed from a small boat using a Phleger Corer. Once retrieved, the sample was placed in a plastic bag, labelled and a solution of 50:50 formaldahyde and distilled water was added. During the collection of samples readings of depth were taken using an echo sounder, a Y.S.I Model 33 S.C.T Meter was used to measure salinity and temperature with a Martek Mark V Water Quality Analyser used to measure pH. In the laboratory samples were washed through a set of three sieves 420μm, 125μm, 75μm and residue from each wash dried at approximately 35°C and allowed to cool. Foraminifera were picked using a fine brush under a binocular microscope. The 75μm fraction was found to contain only a few juveniles (which are a problem to identify as features are indistinct) so this fraction was not examined fully. A coarse fraction (>420μm) of 100cm^3 and a fine fraction (<420μm but >1 25μm) of 50cm were picked, identified and counted from each sample locality. Species classification (Appendix) conforms with Loeblich and Tappan (1988), and with Collins (1974), Parr (1945) and Albani (1968, 1978, 1979) as additional Australian references. Nine of the 34 sample localities were barren of foraminifera.

The foraminiferal population was studied as a total population because the staining of living tissue using Rose Bengal proved to be unreliable, as found by others (Arnold, 1974; Erskian and Lipps, 1977; Quilty, 1977). It has been found that in marginal marine environments dead assemblages closely resemble living ones (Nichols and Ellison, 1967; Nichols and Norton, 1969; Apthorpe, 1980) and these assemblages are considered to be stable over time (Scott and Medioli, 1980). The Clyde River Estuary is a microtidal environment, where vertical mixing is caused by cellular circulation, and little reworking is

	Locality																								
	4	5	7	8	10	11	12	14	15	16	17	18	19	20	21	22	23	25	26	27	28	29	30	31	32
Millammina fusca	6	2	35	6	1	6	1	2	13	1	4	14	1	11										1	
Leptohalysis								2	1																
Protoschista findens	13	6	46	2	2	2		2	6		1	9		1		4	1		1						
Haplophragmoides australensis	6				1				3			3	1	2											
Haplophragmoides canariensis	2	1	1						2																
Trochamminita irregularis	1	1							1																
Ammobaculites agglutinans										1		2			3										
Ammobaculites barwonensis														1	5									1	
Tritaxis conica												2													
Trochammina inflata	2								4	1				1					1						
Spiroloculina lucida																		9				1		10	
Massilina secans tropicalis																								1	1
Quinqueloculina poeyana																		2	19				7	22	2
Quinqueloculina pseudoreticulata																								6	
Quinqueloculina seminula																		5	7					57	1
Quinqueloculina subpolygona																		5	3				2	2	1
Flintina ?sp.																		9	4				2	2	2
Triloculina oblonga																2	1	23	16				3	11	4
Triloculina sp. cf. T. trigonula																							3	1	2
Discorbis australis															5				1		4				
Rosalina australis																		1	10		1		9	1	
Cibicides phillipensis																4	3							5	
Cibicides refulgens																		2	3						7
Nonion depressulus																18	5								
Nonionella auris														4	4	30	13	2	24	6			7	11	1
Ammonia beccarii									1	1				261	621	638	222	43	54	1551	1472	20	190	178	42
Ammonia tepida																5	3		3	57	14			9	
Cribrononion simplex														3	3	64	9		5				1	3	
Elphidium advenum														21	143	112	47	15	10	39	54		9	30	16
Elphidium craticulatus														113	148	654	246		4	87	122	1	1	17	2
Elphidium crispum															5	14		5	6					8	11
Elhidium depressulum														1	6	30	9				8			1	1
Elphidium jenseni																4							10	36	10
Elphidium limbatum																10	3								
Elphidium macellum																	1	1					3	7	3

TABLE 1

Distribution of benthic foraminifera in the Clyde River Estuary

expected. The cellular circulation also prevents the formation of a salt wedge penetrating upstream. The benthic foraminifera were treated as a total population and indeed a sampling in January illustrated this point, as very little change was found in the distribution of benthic foraminifera between January and September.

DISTRIBUTION OF FORAMINIFERIDS

A total of 36 benthic species were recovered from the Clyde River Estuary. The distribution of these foraminiferids is indicated in Table 1. Samples from localities 1A to 19 contained varying numbers of foraminifera. These ranged from zero specimens per $10cm^3$ of sediment (localities: 1A, 1B, 1, 2, 3, 6, 9, 13) to 5.7 per $10cm^3$ of sediment (locality 7). The agglutinated foraminiferids are represented by a total of eleven species and form the only component in localities 4 to 16 (salinity readings 1‰ to 25.5‰). Dominant species include: *Protoschista findens, Miliammina fusca* and *Eggerella australis*. This distribution is common in marginal marine areas and has been found where similar estuarine conditions prevail (Albani, 1968; Murray, 1973; Erskian and Lipps, 1977; Quilty, 1977).

Foraminiferal numbers increase rapidly from locality 20 downstream, especially in the mangrove areas, with 25 species represented. This increase ranged from 1.5 specimens per $10cm^3$ of sediment (locality 29) to 116.7 and 116.0 per $10cm^3$ of sediment (locality 27 and 22 respectively). The Rotaliina dominate this section of the river with *Ammonia beccarii, Elphidium craticulatus* and *Elphidium advenum* the dominant species. *Ammonia beccarii* a widespread euryhaline species inhabiting a broad range of temperature and salinity conditions (Murray, 1991) and often constitutes the dominant species of foraminifera in estuarine environments (Cann and De Deckker, 1981). Maximum abundance of *Ammonia beccarii* occurs in the mangrove areas where oyster leases are also located (localities 20, 21, 22, 23, 25, 26, 27, 28). These areas have a substrate of fine mud and this species has been found in similar conditions elsewhere in Australia (Johnson and Albani, 1973; Apthorpe, 1980; Yassini and Jones, 1989) and on other continents (Murray, 1976; 1991).

Seven *Elphidium* spp. are confined to localities 20 to 32 (salinities range from to 27‰ to 32‰) and identification is often difficult because of extreme intraspecific variation. This group is found on mud and sand substrates with an increase in numbers of *Elphidium craticulatus, E. advenum* and *E. depressulum* on the mud of the mangrove area (localities 20–32, 27 and 28). The miliolina were found in appreciable numbers (6 species) from locality 25 downstream. Miliolina generally prefer marine conditions (Murray, 1973; 1991) and this was reflected in their distribution with salinity readings from 30‰ to 32‰ In the present study the dominant species are represented by *Quinqueloculina seminula, Q poeyana, Flintina* ?sp. and *T. oblonga* and these were found in localities with sand-sized grains.

DISTRIBUTION OF ASSEMBLAGES

Several methods of analysis were used to determine the foraminiferal assemblages in the Clyde River Estuary: Q-mode cluster analysis, the Fisher α Index and the constancy or presence of species. Q-mode cluster analysis (Fig. 2) identified three distinct foraminiferal assemblages. Only benthic foraminifera were used as is the custom in previous analysis of this type (Howarth and Murray, 1969; Johnson and Albani, 1973; Albani and Johnson, 1975; Erskian and Lipps, 1977). Planktonic foraminifera live in the water column and are always transported and then deposited representing an allochthonous population (Murray, 1991; Swanberg and Bjørklund, 1992); whereas benthic species from a microtidal environment, such as the Clyde River Estuary, are accumulated

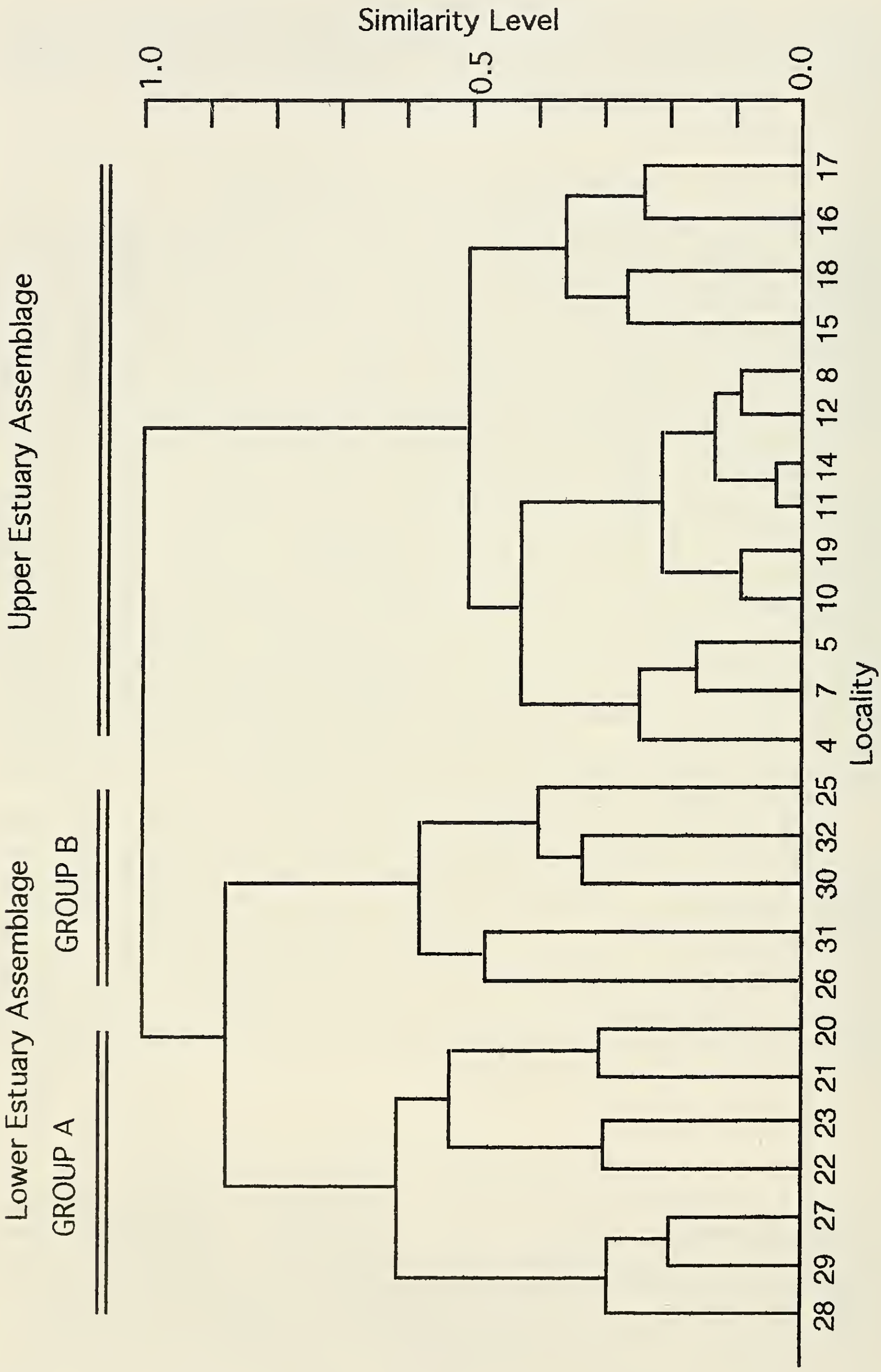

Fig. 2. Q-mode cluster analysis dendrogram of those localities producing benthic foraminifera.

in bottom sediments close to where they live. All 36 benthic species were selected for analysis by Q-mode cluster analysis. When rare species from only a limited number of sites, representing 1% or less of the population (Michie, 1978), were qualitatively analysed a similar distribution of asssemblages was found.

The Fisher α Index (Michie, 1987; Murray, 1991) compares numbers of species and gives a numerical measure of diversity. The benthic foraminifera were examined using this Index to provide a further quantitative analysis of the data. The Fisher α Index revealed that for localities 4 to 19 the diversity was very low in the range of α <1.0 to α 1.0. Localities 20 to 32 showed diversities of between α 3.0 and α 4.5. Diversities of α 4.5 to α 11.0 are found in normal marine conditions (Murray, 1973).

The constancy or presence of species was calculated as a percentage using the expression $C = 100p/P$, where p is the number of samples containing the species and P is the total number of samples studied (Sanchez Ariza, 1983; Bell and Drury, 1992). This expression identifies constant species (>50% of sample locality) accessory species (25–50%) and accidental species (<25%) and was calculated for each Assemblage delinated by the Q-mode cluster analysis.

The Fisher α Index and the calculation of species constancy confirmed the Assemblages delineated using Q-mode cluster analysis. The three foraminiferal assemblages (Fig. 3) in the Clyde River Estuary are: the Upper Estuary Assemblage (localities 4 to 19), and two assemblages in the Lower Estuary — Group A (localities 20, 21, 22, 23, 27, 28, 29) and Group B (localities 25, 26, 30, 31, 32).

Upper Estuary Assemblage

This Assemblage has a low diversity of foraminifera with a textulariid fauna dominating this part of the river. An example of this distribution is represented by locality 10 where *Miliammina fusca, Protoschista findens* and *Eggerella australis* represented 86% of the fauna and at locality 18 these three species represent 89%. These species are the most abundant taxa in all localities in the Upper Estuary with two accessory species (25–50% of sample localities) *Haplophragmoides canariensis* and *H. australiensis*

Lower Estuary Assemblage

This Assemblage (localities 20 to 32) has a more complicated pattern and diversity is higher than in the Upper Estuary Assemblage. These localities are dominated by *Ammonia beccarii, Elphidium craticulatus, Elphidium advenum, Cribronion simplex,* and *Nonionella auris.*

The Group A Assemblage is confined to the southern shore of the river. Apart from the dominant species above, *Elphidium Depressulum* and *Ammonia tepida* were present in over 50% of the sample localities. A small number of accessory species (25–50% of the sample) *Protoschista findens, Eggerella australis, Ammobaculities rostratus, Triloculina oblonga, Discorbis australis, Elphidium crispum, E. limbatum* and *Nonion depressulum* are present in this Assemblage. The textulariids that extend into this Assemblage are represented by at most four specimens and are dominated by the Rotaliina.

The Group B Assemblage spreads from the channel under the bridge (locality 32) and along the northern shore of the estuary and has a large miliolina component (9 species) which is absent in localities further upstream. locality 25 contained 44% milolinid species with 30% at locality 3l. The dominant species, present in over 50% of the sample localities, are *Quinqueloculina seminula, Q. poeyana, Flintina* ?sp., *Triloculina oblonga, T.* sp. cf. *T. trigonula, Rosalina australus, Cibicides reflugens, Elphidium crispum,* and *E. macellum.* This assemblage contains very few accessary species (25–50% of samples) with only *Elphidium jenseni* and *Spiroloculina lucida* represented.

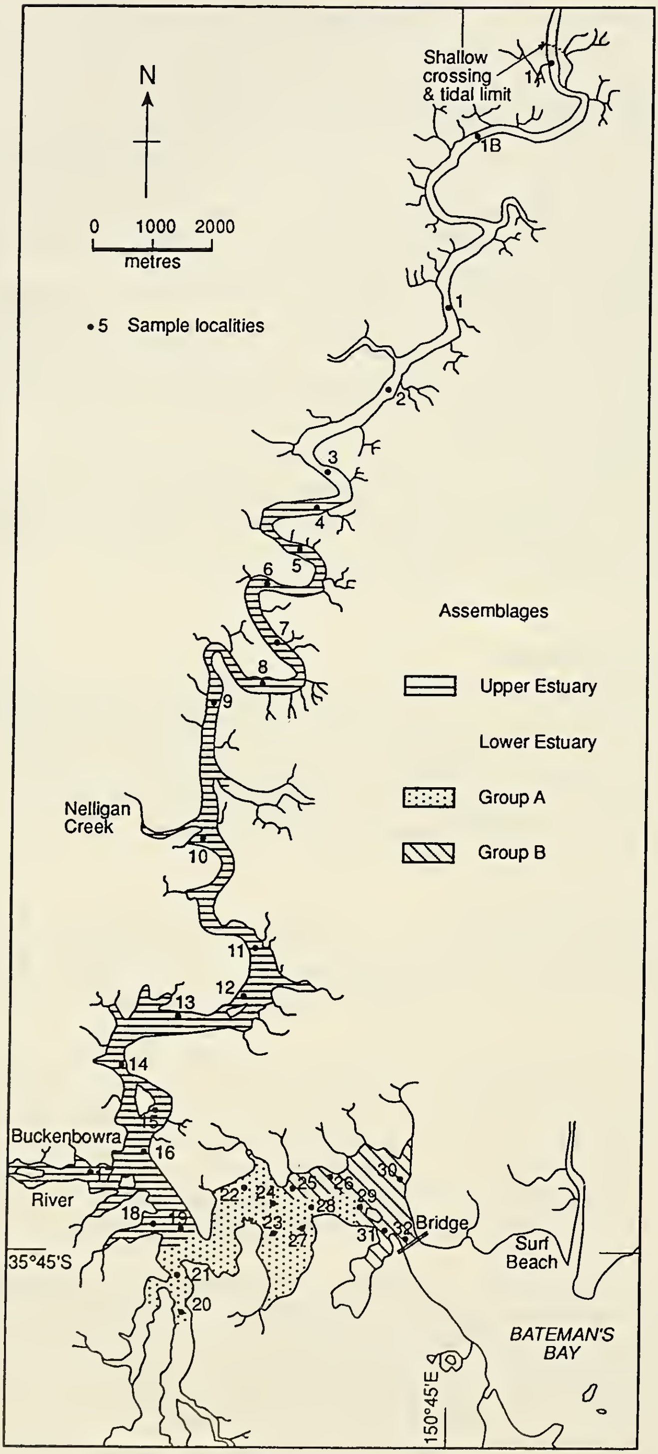

Fig. 3. Benthic foraminiferal assemblages in the Clyde River Estuary.

DISCUSSION

The factors which control distribution of foraminifera in the Clyde River Estuary include salinity, substrate and nutrient supply. Salinity controls the dominance of arenaceous foraminifera in the Upper Estuary and the limit to which calcareous forms can penetrate into lower salinity levels; the miliolina are also constrained by salinity; nutrient supply appears to control the abundance of some species. The association of some species with a particular substrate grain size is discussed below.

Salinity was found to be an important limiting factor of species distribution in the Estuary. The species of foraminifera found are known to be euryhaline; however, the miliolina in the lower Estuary Assemblage are found in a minimum salinity of 30‰ (32‰ marine conditions). Further spot sampling out into the Bay showed that the Lower Estuary Assemblage Group B extends further in that direction. The agglutinated foraminifera are restricted to salinities lower than 28‰ and it is only at higher salinities that calcareous forms begin to appear in large numbers. The two examples of Rotaliina *(Ammonia beccarii)* found in localities 17 and 18 have thinner tests than those found further downstream and this may be the result of lower calcium levels.

Substrate types are known to be a factor in the distribution of invertebrates and it has been shown that sediments rich in clays and muds support a higher density microfauna than larger sediments (Carricker, 1967). With an increase in silt and clay sized particles the number of microfaunal species increases, as does the population density. A sediment analysis revealed that sediment type is associated with the distribution of some foraminifera. In the Clyde River Estuary *Ammonia beccarii* is found in areas with a smaller grain size, the *Elphidium* spp. are found associated with a range of grain sizes while miliolina are only found in areas of larger grain size. Similar findings in the Western Pacific margin have been discussed by Murray (1991). As the population of foraminifera in the river are treated as a total population it is difficult to determine whether the tests are responding to the sedimentary environment, or to the nutrient supplies at that particular locality, or some other unidentified factor. Swanberg and Bjørklund (1992) present evidence which suggests that various sedimentary environments tend to selectively preserve different types of tests. If this is the case then there is a direct response of shell, size and form to the substrate. Several localities did not yield any specimens. The ones present upstream may have been the result of low salinity (localities 1A–3, 6, 9 and 13) the one further downstream (locality 24) is in the tidal channel and the Phleger Corer does not always penetrate coarser sediments (Murray, 1991). locality 29, however, situated in the channel, did yield a small number of tests.

Ammonia spp. and *Elphidium* spp. are known to be herbivores or detritus feeders on mud substrates as these contain an abundance of organic detritus, bacteria and epiphytes (Lipps and Valentine, 1970; Murray, 1991). The largest numbers of these foraminifera in the Clyde River are found in the mangrove areas which have a small sediment size and oyster leases are also present which may contribute to an increased nutrient supply. A similar distribution of foraminiferids has been found in a mangrove environment in other studies (Ludbrook, 1961; Nichols and Norton, 1969).

The benthic foraminiferal assemblages in the Clyde River Estuary can be compared with other studies on the south-east coast of Australia. In Broken Bay NSW, (Albani, 1978) seven biotopes are recognised. The Fluviomarine (B5) Biotope identified by Albani (1978), situated at the entrance to Broken Bay and penetrating upstream, can be compared with the Clyde River Lower Estuary-Group B Assemblage. The species in common are *Quinqueloculina subpolygona. Triloculina oblonga, Elphidium crispum, E. depressulum* and *Cibicides refulgens*. Broken Bay and the Clyde River Estuary appear to have a similar distribution of foraminifera, although Broken Bay has a large wide opening to the open ocean. In comparison the Clyde River has a more restricted opening which does not allow the penetration of the miliolina upstream as in Broken Bay. The Upper Estuary Assemblage of the Clyde River Estuary is absent from Broken Bay which

does not have a long meandering river system like the Clyde and the arenaceous fauna are therefore absent. However, further sampling in the Hawkesbury River may reveal this fauna further upstream.

In the Gippsland Lakes system (Apthorpe, 1980) salinity was found to be the most important controlling factor influencing the distribution of foraminifera. A Semi marine Fauna produced ten different miliolina, the most common being *Quinqueloculina seminulum*, and *Triloculina trigonula*, with *Elphidium advenum*, *E. macellum* and *Ammonia aoteanus* (which Apthorpe (1980) considers is a possible cool temperate water morphotype of *A. beccarii)*, all of which are also found in the Clyde River Estuary in a similar environmental and areal distribution. The extent of the Gippsland Lakes System makes comparison difficult and only general statements are possible. The arenaceous fauna is controlled by salinity in both systems with *Elphidium* spp. represented on both sandy and muddy substrates as in the Clyde River.

The coastal lagoon of Lake Illawarra NSW (Yassini and Jones, 1989) has four distinct assemblages. Although both this area and the Clyde River Estuary have a restricted tidal circulation the areal extent of each is very different and comparison is not a simple matter. The long meandering nature of the Clyde River for much of its length confines the textulariids to this low salinity region regardless of the substrate. Both show a dominant Miliolidae assemblage in areas of marine salinity and sandy substrate.

Definition of the benthic foraminiferal assemblages in the Clyde River Estuary provides a more detailed analysis of the south-east coast of Australia. Comparison with other studies described above, which are to the north and south of the Clyde River Estuary, allow a comprehensive understanding of not only foraminiferal distribution but also the factors which control that distribution. There is an association between salinity levels and the distribution of Textulariina, Miliolina and Rotaliina foraminifera. The grain size of the substrate and nutrient supply appear to be linked to the distribution of some foraminifera in the Clyde River Estuary.

ACKNOWLEDGEMENTS

I wish to thank Mr. Ken Bell for useful taxonomic discussions and comments on the manuscript. Dr. Theresa Winchester-Seeto and Prof. Malcolm Walter for helpful discussion of the manuscript. Dr. G.C.O. Bischoff for fruitful discussions and Ms. Judy Davis for drafting.

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APPENDIX

Taxonomic Notes

Brief notes on selected species are presented below either because their identification presented problems or their presence is of note.

Order: FORAMIMFERIDA Eichwald, 1830
Suborder: TEXTULARIINA Delage and Hérouard, 1896
Family: HORMOSINIDAE Haeckel, 1894
Genus: *Leptohalysis* Loeblich and Tappan, 1984
Leptohalysis sp.
(Figure 4., No. 5.)
Remarks: This is a small delicate species described by Collins (1974) as *Reophax* sp. A from Port Phillip Bay. Victoria. It is similiar to *R. catella* Höglund, 1947 but is smaller with a larger number of chambers. The species has also been described by Bell and Drury (1992) as *Leptohalysis* sp. occurring in Western Port and the Mallacoota Inlet, Victoria. Leoblich and Tappan (1984) transferred the *R. scotti* group to which this species is related to the Genus *Leptohalysis*. Three specimens are present at localities 14 and 15 in the Clyde River Estuary and these resemble *Leptohalysis* sp. (Bell, 1994, pers. comm.)

Suborder: MILIOLINA Delage and Hérouard, 1896
Family: HAUERINIDAE Schwager, 1876
Genus: Flintina Cushman, 1921
Flintina ?sp.
(Figure 5., No.4.)
Remarks: This is a very distinctive species with rounded inflated chambers and a broadly rounded periphery. It appears to have a triloculine arrangement of chambers. The porcelaneous, imperforate wall has many fine striae running longitudinally. The aperture is large with a bifed tooth and is flush with the surface. This individual may represent an early stage of this (Loeblich and Tappan, 1988). It is present in localities 25, 26, 30–32 and represented by 19 specimens.
Genus: *Triloculina* d'Orbigny, 1826
Triloculina sp. cf. *T. trigonula* Lamarck, 1804
(Figure 5., No.1.)
Remarks: This species resembles *T. trigonula* in every respect except that the apertural lip projects in onto the stem of the bifed tooth. It is present in localities 30–32 and represented by six specimens.

The following is a list of the remaining species of benthic foraminifera recovered from the Clyde River Estuary at Bateman's Bay. Classification follows that of Loeblich and Tappan (1988).

Suborder: TEXTULARIINA Delage and Hérouard, 1896
Family: RZEHAKINIDAE Cushman, 1933
Genus: *Miliammina* Heron-Allen and Earland, 1930
Miliammina fusca Brady, 1870

Family: THOMASINELLIDAE Loeblich and Tappan. 1984
Genus: *Protoschista* Eimer and Fickert, 1899
Protoschista findens Paker, 1870

Family: HAPLOPHRAGMOIDIDAE Maync,1952
Genus: *Haplophragmoides* Cushman, 1910
Haplophragmoides australensis Albani, 1978
Haplophragmoides canariensis d'Orbigny, 1839
Genus: *Trochamminita* Cushman, Cushman and Brönnimann, 1948
Trochamminita irregularis Cushman and Brönnimann, 1948

Family: LITUOLIDAE de Blainville, 1827
Genus: *Ammobaculites* Cushman, 1910
Ammobaculites agglutinans d 'Orbigny, 1846
Ammobaculites barwonensis Collins, 1974

Family: TROCHAMMINIDAE Scwager, 1877
Genus: *Tritaxis* Schubert, 1921
Tritaxis conica Parker and Jones, 1865
Genus: *Trochammina* Parker and Jones, 1859
Trochammina inflata Montagu, 1808

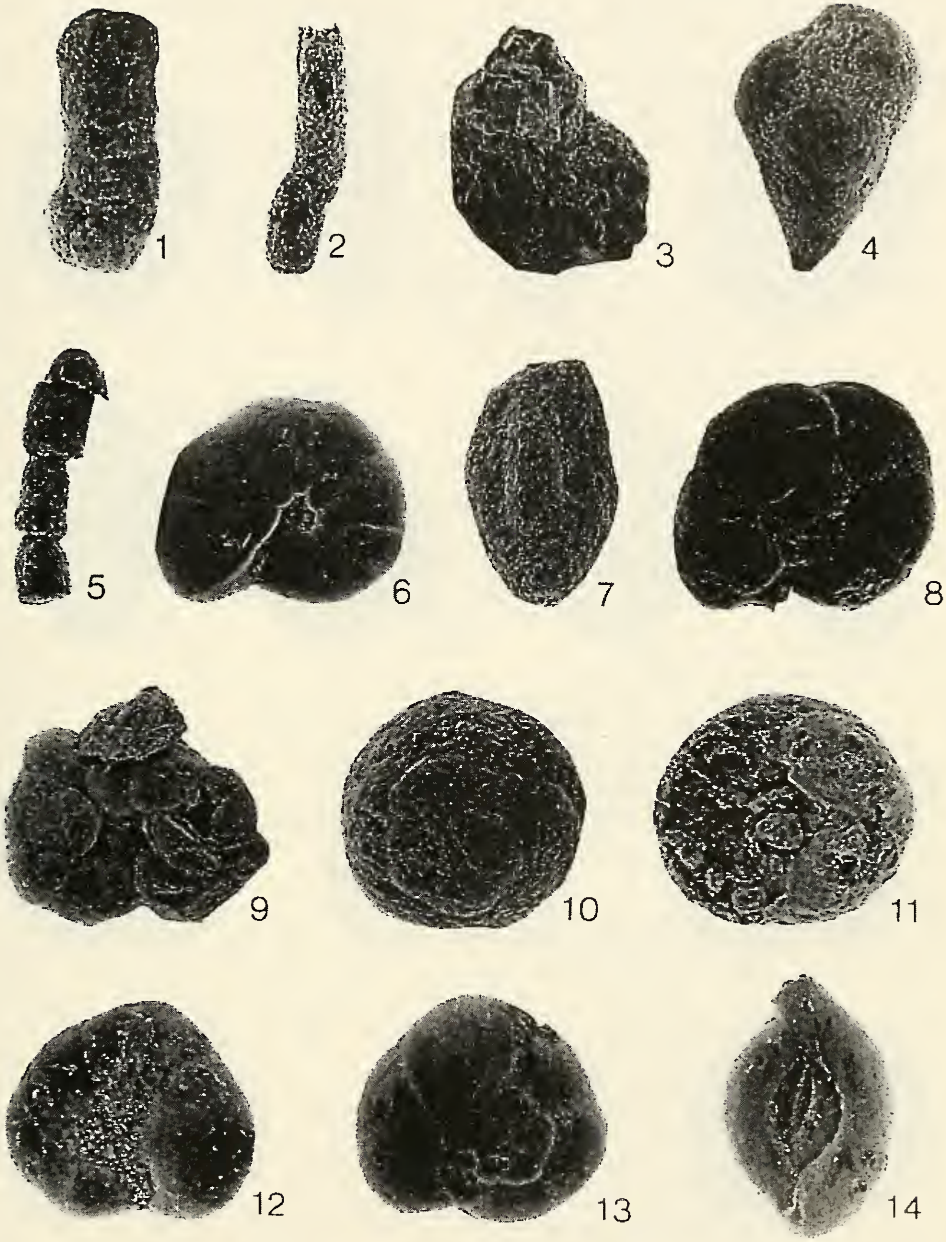

Fig. 4. **1.** *Ammobaculites agglutinans*, x55; **2.** *Protoschista findens*, x45, deformed specimen; **3.** *Ammobaculites barwonensis*, x56; **4.** *Miliammina fusca*, x60; **5.** *Leptohalysis* sp., x100, top chamber broken; **6.** *Haplophragmoides canariensis*, x50; **7.** *Eggerella australis*, x71; **8.** *Haplophragmoides australensis*, x32; **9.** *Trochamminita irregularis*, x50; **10,11.** *Tritaxis conica*, x68, spiral and umbilical views; **12,13.** *Trochammina inflata*, *x55*, umbilical and spiral views; **14.** *Spiroloculina lucida*, x31.

Family: EGGERELLIDAE Cushman, 1937
Genus: *Eggerella* Cushman, 1935
Eggerella australis Collins, 1958

Suborder: MILIOLINA Delage and Hérouard, 1896
Family: SPIROLOCULINIDAE Wiesner, 1920
Genus: *Spiroloculina* d'Orbiguy, 1826
Spiroloculina lucida Cushman and Todd, 1944

Family: HAUERINIDAE Schwager, 1876
Genus: *Massilina* Schlumberger, 1893
Massilina secans tropicalis Collins, 1958
Genus: *Quinqueloculina* d'Orbiguy, 1826
Quinqueloculina poeyana d'Orbigny. 1939
Quinqueloculina pseudoreticulata Parr, 1941
Quinqueloculina seminula Linné, 1758
Quinqueloculina subpolygona Parr, 1945
Genus: *Triloculina* d'Orbiguy, 1826
Triloculina oblonga Montagu, 1803

Suborder: ROTALIINA Delage and Hérouard, 1896
Family: PEGIDIIDAE Heron-Allen and Earland, 1928
Genus: *Discorbis* Lamarck, 1804
Discorbis australis Parr, 1932

Family: ROSALINIDAE Reiss, 1963
Genus: *Rosalina* d'Orbigny, 1826
Rosalina australis Parr, 1932

Family: CIBICIDINAE Cushman, 1927
Genus: *Cibicides* de Montfort, 1808
Cibicides phillipensis Collins, 1974
Cibicides reflugens de Montfort, 1808

Family: NONIONIDAE Schultze, 1854
Genus: *Nonion* de Montfort, 1808
Nonion depressulus Walker and Jacob, 1798
Genus: *Nonionella* Cushman, 1926
Nonionella auris d'Orbigny, 1839

Family: ROTALIIDAE Ehrenberg. 1839
Genus: *Ammonia* Brünnich, 1772
Ammonia beccarii Linné, 1758
Ammonia tepida Cushman. 1926

Family: ELPHIDIIDAE Galloway, 1933
Genus: *Cribrononion* Thalmann, 1947
Cribrononion simplex Cushman, 1933
Genus: *Elphidium* de Montfort, 1808
Elphidium advenum Cushman, 1922
Elphidium craticulatus Fichtel and Moll, 1798
Elphidium crispum Linné, 1758
Elphidium depressulum Cushman, 1933
Elphidium jenseni Cushman. 1924
Elphidium limbatum Chapman, 1909
Elphidium macellum Fichtel and Moll, 1738

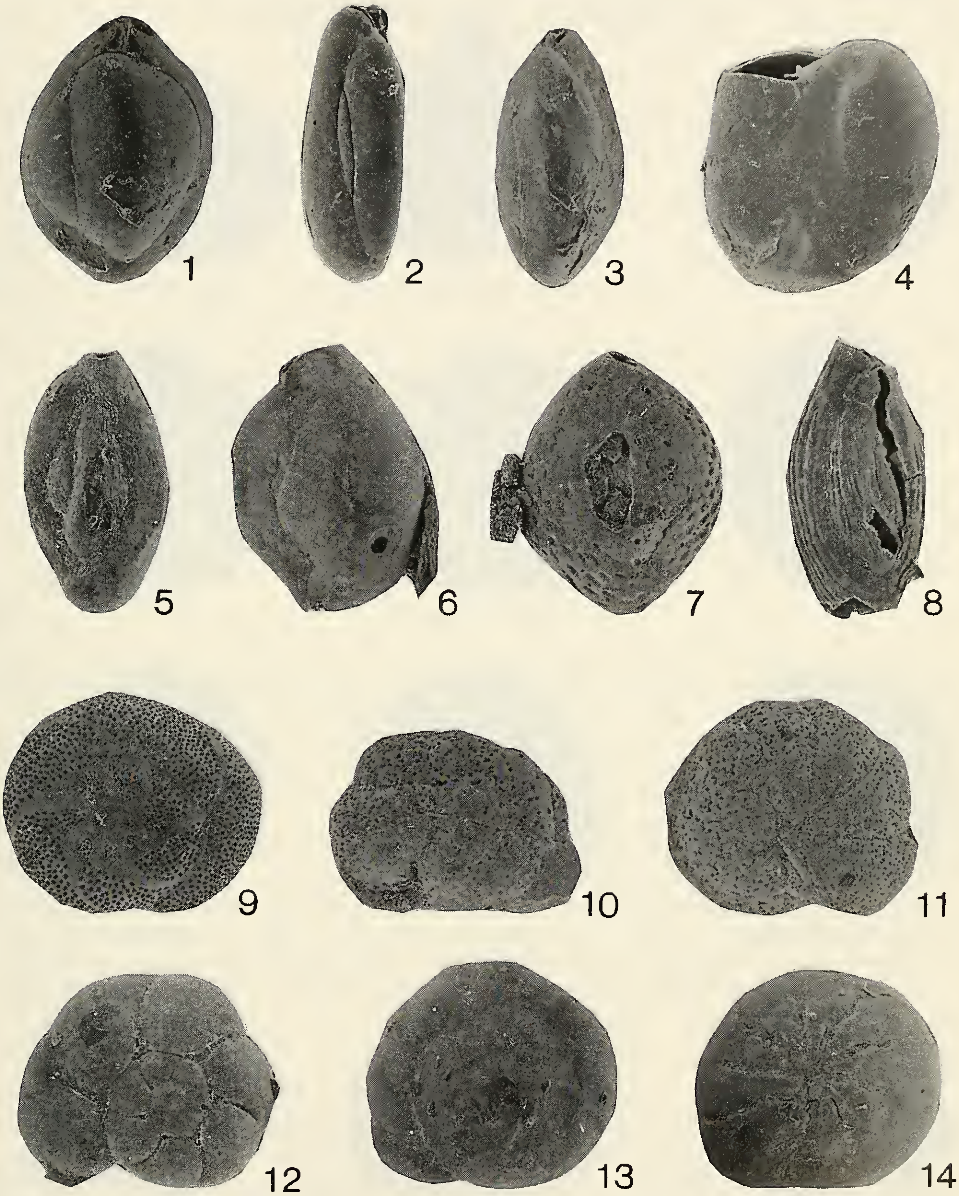

Fig. 5. **1.** *Triloculina* sp. cf. *trigonula*, x58, showing aperture; **2.** *Triloculina oblonga* x68; **3.** *Quinqueloculina seminula* x35; **4.** *Flintina* ?sp., x33. showing aperture; **5.** *Quinqueloculina subpolygona* x30; **6.** *Massilina secans tropicalis* x70; **7.** *Quinqueloculina pseudoreticulata* x28, damaged specimen; **8.** *Quinqueloculina poeyana* x55, damaged specimen; **9.** *Discorbis australis*, x46; **10.** *Rosalina australis*, x52; **11.** *Cibicides phillipensis*, x47; **12.** *Cibicides reflugens*, x48; **13,14.** *Ammonia beccarii*, x45, spiral and umbilical views.

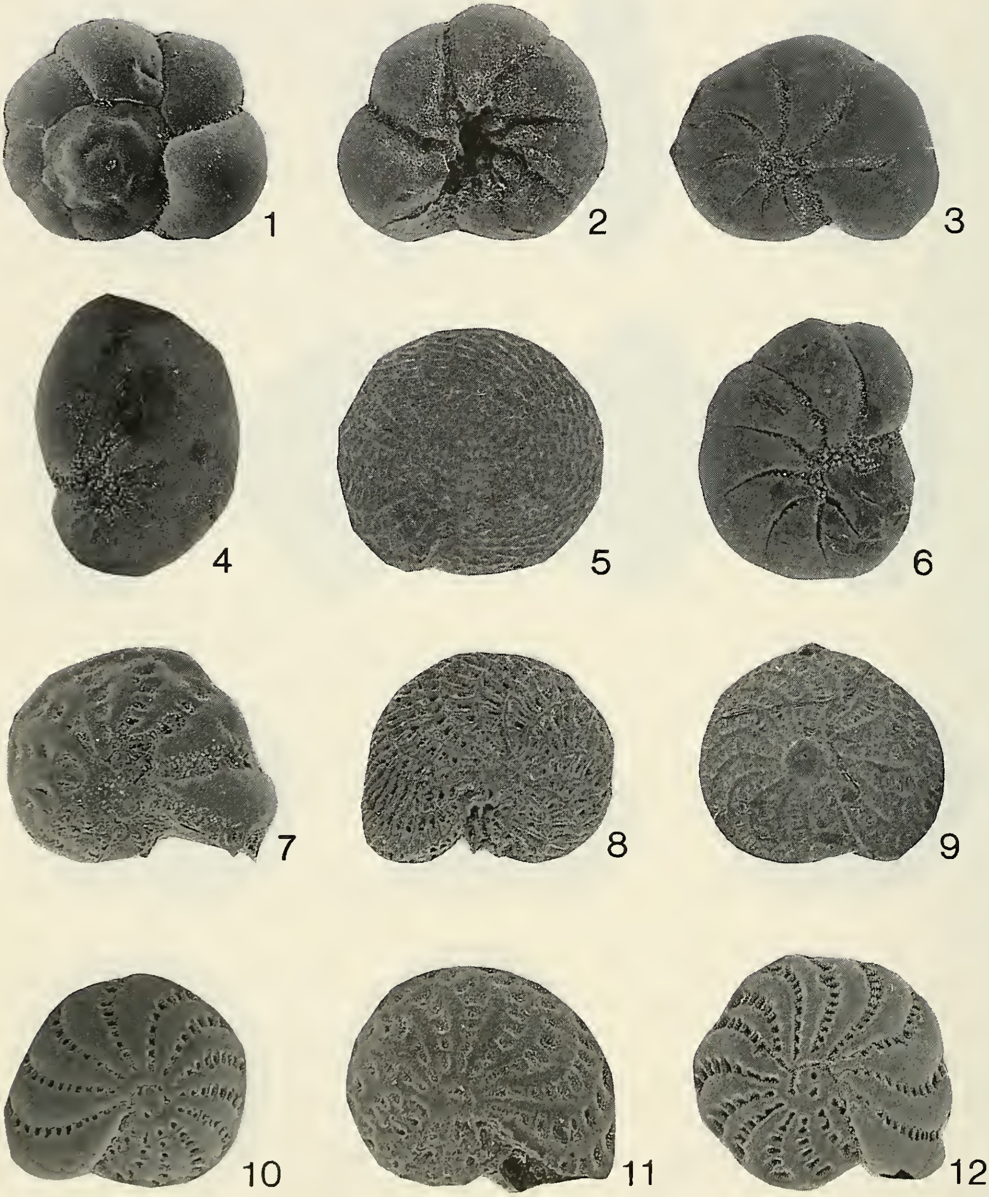

Fig. 6. **1,2.** *Ammonia tepida* x83, spiral and umbilical views; **3.** *Nonionella depressulus,* x85; **4.** *Nonionella auris* x78; **5.** *Elphidium craticulatus,* x22; **6.** *Cribrononion simplex,* x76; **7.** *Elphidium limbatum,* x41; **8.** *Elphidium jenseni,* x33; **9.** *Elphidium macellum* x60; **10.** *Elphidium advenum* x84; **11.** *Elphidium crispum* x38; **12.** *Elphidium depressulum* x78.